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Observations of the Reappearance of the Rings of Saturn; Observations of the Position-Angles of the Rings, and Observations of the Satellites. By E. E. Barnard.

The conditions for observation at the reappearance of the rings of *Saturn* in 1891 were somewhat better than those at the disappearance in 1878. Neither the reappearance of 1878 nor the disappearance of 1891 could be observed on account of the proximity of the planet to the Sun.

At the present reappearance of the rings, the planet was situated in the morning sky, two hours and a half west of the Sun, and in three and a half degrees north declination.

From Professor Hall's valuable memoir on *Saturn* (being Appendix II. of *Washington Observations for* 1885) we learn that with the 26-inch the rings were wholly invisible at the disappearance of 1878, except where they were projected on the ball of the planet. Since the reappearance of *Saturn* from the region of the morning Sun, I have examined it carefully a number of times with the 12-inch, and on two occasions, when the opportunity permitted, with the 36-inch.

Up to October 29, on no occasion, with the most careful scrutiny and good seeing, was it possible to detect the slightest trace of the rings projected on the sky, though they appeared as a heavy black band crossing the planet and apparently cutting it nearly in halves.

On October 22 *Saturn* was carefully examined with the 36-inch, but the rings were equally invisible in that instrument. The observations extended from $17^h\ 15^m$ to $18^h\ 15^m$ Standard Pacific time (8^h slow of Greenwich). The seeing was 3 on a scale of 5 for perfect steadiness. The projection of the ring on the ball was perfectly black. The edges were sharp and perfectly free from irregularities, and no evidence of the crape ring was seen. The southern edge of the trace was slightly convex. Only one belt was visible, and that was some $3''$ south of the ring.

I very carefully measured the width of the projection of the ring at its middle part on the ball. This could be done with great accuracy by placing the wires so that their outer edges exactly filled the black trace, the measures being corrected for the thickness of the wires ($0''\cdot12$). The resulting value, at $18^h\ 0^m$, gave the width of the middle of the projection $= 0''\cdot51$. This agrees exactly with the value derived from the data in the American Ephemeris ($0''\cdot51$).

The measured distances of the centre of the projection from the polar limbs of *Saturn* were

From north limb $= 7''\cdot40$
From south limb $= 6\cdot56$

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At the observations on this date the earth was 1°36′ north of the plane of the rings, and the Sun 0°8′ south.

October 26, I examined the planet carefully with the 12-inch. The seeing was nearly perfect (from 4 to 5). With magnifying powers of 150–175–500 there was no trace of the ring against the sky. I was struck at this observation, however, with a phenomenon that may be very important in dealing with observations of the ring at and near disappearance. Looking at the black trace on the ball, and then glancing at the sky near the sides of the planet, I could, apparently, see the rings for a moment as a faint line of light on the dark sky. I satisfied myself beyond question that this was an optical phenomenon.

Perhaps everyone is familiar with the "after image" produced by looking, say, at the sash of a window when projected on a bright sky from a more or less darkened room. After gazing at the window for a few moments and then turning the eyes to a dark part of the room, a perfect image of the window sash appears, the lines being white, however, instead of black as in the window.

This phenomenon was easily produced by looking at the black line across the bright disc of *Saturn*, and then glancing at the dark sky where the ring ought to appear. I mention this, as it might some time mislead an observer, who would think he had glimpsed the real ring. Perhaps this same phenomenon has a bearing on other kinds of astronomical observations.

October 27 and 28 were cloudy.

On October 29 the planet was observed with both the 12- and 36-inch refractors. At $17^{h}\ 0^{m}$ Mt. Hamilton mean time, with the great telescope, the rings were easily and distinctly visible as slender threads of light. It was not possible, however, to see them at their junction with the ball, they being invisible for a space of about 2″ through nearness to the bright disc of *Saturn*. Perhaps this was also due to the fact that the ansæ would be brighter at a distance equal to the inner edge of the bright rings.

Continuing the lines of light, they would have joined the planet slightly north of the north edge of the trace of the rings on the ball, as I have shown in the drawing for October 29.

On this date I again measured the projection of the rings on the ball.

Middle width = 0″·65

According to the American Ephemeris, this value at that time was 0″·63.

At $17^{h}\ 30^{m}$ I examined the planet with the 12-inch. The rings, though faint, were distinctly visible, but much less conspicuous than in the large telescope.

At the observation of this date the earth was 1°58′ north of the plane of the rings, while the Sun was exactly in their plane, according to the Ephemeris.

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The following notes were made, among others, during these observations:—

October 29.—The following ansa appears the brighter. There are two little lumps on the south edge; possibly two satellites. Rings not seen up to ball. They would touch the planet, if continued, *north* of their trace on *Saturn.*

November 3.—The preceding ansa is the brighter, and appears uneven. Rings cannot be seen up to ball; continued, they would pass *north* of their trace on the planet. The rings are very pale and their light weak, compared with the ball. Trace very black.

November 5.—Possibly the following end is the brighter.

November 6.—Possibly the following end is the brighter.

In all the observations the projection of the ring on the ball was perfectly black, and no trace of the division could be seen.

In the drawing of October 29 I have not attempted to show the two inequalities on the following ansa. They were quite difficult, and any attempt to show them on the drawing would be an exaggeration. I therefore append a small diagram, given on the plate, which will show their position. I assume they were two of the inner satellites.

No spots, dark or light, have been seen on the ball of *Saturn* at any time during the observations.

The observations with the two telescopes during October confirm the extreme thinness that has been attributed to the rings. Under more favourable circumstances of observation it is possible that they may be visible in the 36-inch, but at the disappearance of the past year they were certainly beyond reach of both instruments.

It is probable that the rings are less than 50 miles in thickness.

In *Monthly Notices* for January, 1892, Professor Oudemans gives an account of his observations of the reappearance of the rings of *Saturn* with the 9½-inch equatoreal of the Utrecht Observatory.

Professor Oudemans says that on October 29^{d} 17^{h} 30^{m} (= October 29^{d} 9^{h} 3^{m} Mt. Hamilton M. T.) *Saturn* was decidedly without any ring. October 30 was cloudy, but on October 31, at 17^{h} 30^{m}, a momentary view showed the ring at both sides of the planet as a thin bright line.

Combining my observations of October 29 with those of Professor Oudemans for the same date, it is evident that the time of reappearance of the ring is narrowed down to the interval between 9^{h} 3^{m} and 17^{h} 0^{m}, October 29^{d}, 1891, Mt. Hamilton M. T. The American Ephemeris gives October 30 as the time of reappearance.

In the *Monthly Notices* for November, 1891, the Rev. Mr. Freeman has given his observations of the reappearance of the ring with a 6-inch refractor.

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October 29^{d} 18^{h} 10^{m} to 18^{h} 35^{m} G. M. T., he saw nothing of the ring.

October 30^{d} 18^{h} 25^{m} to 18^{h} 35^{m} he was also unsuccessful.

But on November 1^{d} 17^{h} 30^{m} G. M. T., he plainly saw it as a fine bluish line of light. From his observations he deduces October 31^{d} 18^{h} G. M. T., 1891, as the time of the passage of the plane of the rings through the Sun.

Mr. Freeman's telescope was too small to show the ring early enough, and his data will therefore be insufficient to determine the position of their plane.

Position Angles of the Rings.

In the *Astronomical Journal*, No. 246, I have given a number of measures of the position angles of the rings of *Saturn* with the 12-inch, and a comparison with the American Ephemeris values.

From these observations (on thirty nights) I deduced a correction of $-3'{\cdot}36 \pm 1'{\cdot}68$ to the position angles derived from the Ephemeris. Since the reappearance of the rings I have continued these measures. Following are the observations so far continued:—

Observations of the Position Angles of Saturn's Rings.

1891–92.	Mt. Hamilton M.T.	P.A.	Set.	See.	C–O.
	h m	°			°
Oct. 22	17 30	85·70	4	3	−0·23
29	17 30	86·10	5	...	−0·55
Nov. 3	17 8	85·83	5	5	−0·19
5	17 33	85·46	5	2	+0·13
6	17 0	86·14	4	2–3	−0·54
21	17 27	85·62	5	2	+0·11
27	17 30	85·76	5	4	+0·01
Jan. 10	14 4	86·03	4	4–5	−0·12
Mar. 8	15 57	85·69	5	4–5	0·00
9	8 54	85·75	5	5	−0·07
16	9 26	85·68	5	4–5	−0·05
		Mean deviation	...	...	−0·14

These observations give a correction of

$$-8'{\cdot}40 \pm 1'{\cdot}02$$

to the Ephemeris.

The measures in October and the first part of November were made under unfavourable conditions compared with those printed in the *Astronomical Journal*, and should have less weight.

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Conjunction of the Satellites with the Ring.

The following observations of the satellites of *Saturn* have been made. These observations will be continued. Absence from the Observatory during the latter part of January, February, and a part of March has prevented more observations of the satellite so far this year.

Conjunction of Tethys and following end of Ring.

1892.	h	m	s	
Jan. 10	14	9	18	*Tethys* ½ thickness of wire following.
	14	12	43	,, ¼ ,, ,, ,,
	14	15	53	Conjunction.
	14	19	28	*Tethys* past conjunction by ¼ thickness of wire.
	14	22	58	,, ,, ,, ½ ,, ,,

preceding thickness of wire 0″·44. Mag. power 175 on 12 in.

Conjunction of Rhea and following end of Ring.

Rhea North.

	h	m	s	
Jan. 22	15	28	11	*Rhea* 1 thickness of wire preceding end of Ring.
	15	31	31	,, ½ ,, ,, ,, ,,
	15	35	31	*Rhea* in conjunction with following end of Ring.
	15	42	21	½ thickness of wire following end of Ring.
	15	47	21	1 ,, ,, ,, ,,

In these observations the micrometer wire was made vertical to the ring. The moment of conjunction could be quite closely observed, as any displacement was easily seen by bisecting the satellite or the end of the ring.

Mount Hamilton:
1892 *March* 17.

Note on the Transit of Titan, 1892, *March* 11. By Arthur Mee.

This evening, with pretty fair definition, I had been observing the Moon, and afterwards (about 10.15) turned my 8½ in. Calver equatoreal on *Saturn*. I immediately saw, a little way within the southern limb, and slightly east of the meridian, a dark spot, and almost immediately afterwards a brown spot still further to the east. I watched the pair with powers 200–400 till I had to leave the telescope. The dark spot seemed central at 10.30. Looking up the almanac next day, I found the dark spot was the shadow of *Titan* in transit, and it at once occurred to me that